Cat 6 mo ↑ symptoms: Online Physician Charting and More.

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The physicians of the Children's Asthma Center and the computer scientists of Information Services at Texas Children's Hospital set out to design a system that is comfortable to use, structured enough to effectively measure outcomes, yet flexible enough to conserve the individuality of the patient. To achieve these goals, we examined how the differential diagnosis process is applied to clinical decision making and implemented it in a clinical workstation. Unique patterns representing the state of the patient's disease are formed by dynamically selecting pertinent sets of observations, assigning attributes to these observations, and describing relationships between observations and/or sets of observations.

INTRODUCTION

The Texas Children's Hospital Information Systems Strategic Plan incorporates five key objectives for information technology:

- support of continuity of clinical care
- protection of patient data
- integration of data
- guided decision making
- outcome and cost analysis

In support of these objectives, a pilot clinical workstation project was begun by Information Services (IS) in November, 1994. The basic goals of the Texas Children's Clinical Workstation (CWS) are to analyze, implement and evaluate methodologies for:

- constructing a centralized, structured data repository
- interfacing with existing hospital ancillary systems such as the ADT system
- providing online, interdisciplinary clinical charting using a graphical user interface (GUI)
- developing processes such as data entry, updating and report printing that comply with regulatory standards

The knowledge gained from the pilot was utilized in the development of functional and technical specifications for the purchase of a hospital-wide clinical information system.

Two outpatient clinics, the Children's Asthma Center (CAC) , and the Texas Children's Cancer Center (TCCC), were selected for the pilot CWS project. The clinics differ greatly in process and focus. The TCCC is a high volume intervention oriented clinic. The CAC is primarily focused on patient education and clinical research. The scope of this paper will be limited to the design and implementation of online physician charting in the CAC.

An interdisciplinary, interdepartmental team consisting of computer scientists, physicians, nurses, and researchers met several hours weekly to design the specifications for the system. The first release of the CWS in August, 1994 included the computerization of the nurses' charting, the interdisciplinary education documentation, phone logs, discharge summary information and associated medical record reports. The second major release, scheduled for September, 1995, includes physician charting, electronic chart signature, order entry for take home prescriptions, The Asthma Action Plan, and the associated medical record reports.

Much of the nurse's charting consisted of demographic, historical, and some marketing information. Forms developed by the CAC were further structured and translated into a windows GUI. As the design team began to discuss physician charting, it soon became evident that this approach was not adequate. A subgroup of physicians and analysts formed to discuss the issues involved in

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depth. The initial challenge issued to this subgroup was to make online charting as easy, fast, and succinct as writing "Cat 6 mo ↑ symptoms."

THE ISSUES

Surprisingly, the impasse the design team hit reflected more concern over the current medical/legal paradigm than about the actual data content. The institutionalized notion of "what a chart is" presented information about the clinical process in a discontinuous, redundant, incomplete and cumbersome manner. In response, physicians developed very individualized charting methods. The flexibility of essentially "free text" forms allowed for great variance in the completeness, complexity, location, and annotation style of information in the chart. Clinicians, while charting, often would encompass a whole column of values with one circle or would annotate in a margin of a crowded page. It was fast and concise.

Although structured data entry was a design goal from the pilot's inception, there was a fair amount of apprehension among the physicians that it would be labor intensive and would disrupt both the clinical process and their own thought processes. An informal survey conducted by Information Services of how physicians chart confirmed that, in applying the differential diagnosis process, many observations, relationships and intermediate decisions were implicit. The physicians viewed the whole clinical process as a continuum. Consciously tracking every decision path and sectioning data was disruptive and not representative of their thought processes. Different levels of certainty were associated with different stages of the differential process and these, too, needed to be captured online. Almost all the physicians surveyed had some method of collecting pertinent notes - often just keywords - about the patient before finalizing it in the medical record. The CWS would need to incorporate some kind of personalized scratch pad into its design.

Potential litigation issues were raised. There is no charting by default, that is, explicit actions must be taken to assign values to data items. Replacing the one circle drawn around all the "normals" in the Review of Systems form with twenty mouse clicks was unacceptable. Equally unacceptable was leaving items blank or assigning a value of "not examined" because of the potential appearance of negligence by omission. Free text was not considered an option as it would not provide reusable, quantifiable information.

As academicians, the CAC physicians felt they had a mandate to implement "good practice procedures" to educate medical students, residents, and fellows. Solutions acceptable to attending physicians such as an "all normal" button did not require enough explicit attention to detail by students and residents. Any design specifications would have to accommodate the different levels of clinical expertise.

Finally, the CAC was a new clinic, barely a year old. Its forms and subgroups were evolving in parallel with the CWS design. The design meetings, with broad clinical representation, became a catalyst for the standardization of terms and the coordination of forms and processes within the clinic. Team ownership of the chart and the problem list was a natural extension of the clinic's commitment to an interdisciplinary approach to education in the self management of asthma. A requirement of the CWS would be that "all voices could be easily heard."

The group introspected about how clinicians thought and struggled with balancing the advantages of technology with deeply ingrained traditions in medical charting to design a usable system. What emerged was a unique solution to online physician charting.

THE SOLUTION

The primary goal from a clinical standpoint was to be able to view, at a glance, a unique pattern representing the state of a patient's disease. Following Rector, Nowlan, and Kay, the fundamental requirement for building this pattern would be "the faithful recording of what was observed and believed by clinicians."[1]

Using a set metaphor was the basis of the solution. These sets are hierarchical. They allow clinicians to chart at the level of abstraction that they are comfortable with and to pick only the pertinent information for that patient.[1] Pertinent here can mean positives or negatives. The physician essentially individualizes the format of the chart for each patient. This is important because it eliminates any charting by default. On reports only pertinent information is printed, there are no blank items. This reduces the appearance of negligence by omission.

The sets of observations are created dynamically. Observations can be anything on the chart that is significant for that patient, for example, medications, caregiver comments, or diagnostic imaging results. Observations are categorized within a tree structure. This categorization also serves to standardize the medical terminology used in the chart. Navigation through the chart is accomplished by branching from one part of the tree to any other part. Again, the physician can dynamically drive the process. Illustrated below is a fragment of the tree:

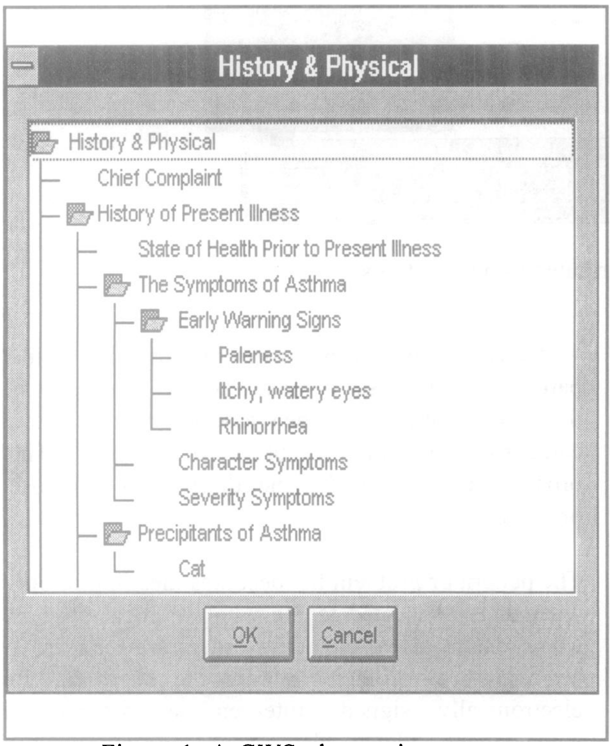

Figure 1. A CWS observation tree

The design group supplied lists of common observations for each category. For example, the set of Early Warning Signs of Asthma include "paleness", "itchy watery eyes", and "rhinorrhea." These observations serve as a model of good practice and as a teaching tool. New observations can be added dynamically to each set.

The "root" of the tree depicted in Figure 1 is "History and Physical." "Chief Complaint" and "History of Present Illness" are children of "History and Physical."

All categories and all observations are instantiated as objects. All objects have sets of potential attributes, i.e., identifying characteristics, associated with them. Again, the clinician picks only those attributes that are pertinent to that patient. Objects inherit appropriate attributes from their ancestors on the tree. In the above example, "The Symptoms of Asthma" may have associated attributes such as "Seasonality," "Course," and "Periodicity." If a physician charts a seasonality profile of "Fall and Spring", then the children of "The Symptoms of Asthma", e.g., "Early Warning Signs," inherit this value. This allows a physician to chart once at a suitable level of abstraction. The inherited seasonality profile may be overridden by charting a different set of values for the seasonality attribute of the observation where the exception occurs. For example, assigning a seasonality profile of "Winter" to "itchy, watery eyes" will give that value precedence over the inherited value of "Fall and Spring." Students and residents might be required to chart at the observation level as part of the educational process. (See Figure 2.)

Every change, addition, or strike-through to an object is annotated (with a date/time user stamp) and visible as part of the history of that object. The history of an object is available longitudinally across occurrences. All occurrences show the whole interdisciplinary conversation about that object.

Categories, observations, or sets of observations can be dynamically related to each other. For example, in "Cat 6 mo ↑ symptoms", two sets of observations are represented. "Cat " is an observation in the set of "Precipitants of Asthma" and "symptoms" refers to the set of "The Symptoms of Asthma" for that patient. One of the attributes of "Cat" is that it has been associated with the patient for six months. The element "Cat" relates to the set of "The Symptoms of Asthma" by increasing its severity.

Technically, these object-oriented features are implemented in a relational database. An object usually has an associated set of attributes and a set of methods, i.e., code that may be executed to perform requested services. In the data repository, an object is defined by three relational tables, "object" and "object_attribute" and "attribute value." The set of methods for each object is used to manipulate the object. The CWS utilizes stored procedures to accomplish this.

One of the major problems of mapping object-oriented design to relational data modeling is how to

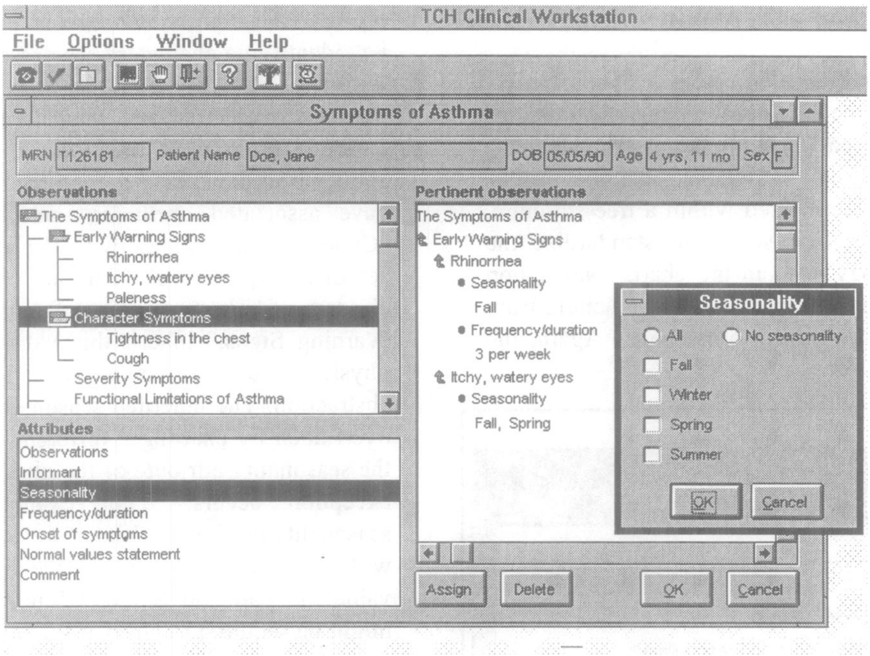

Figure 2. Assigning attributes to observations.

define the relationship between objects in the database, for example, between the category "Precipitants of Asthma" and the observation "Cat." The logical database design is analogous to the interface design in that it uses a tree structure. The root represents the highest level of the object. Any children inherit from the root. Each object has a pointer to its parent object. By defining such structures, information about the object and its relationship to other objects is captured. Accessing information about an object stored in this manner requires the retrieval of multiple result sets based on complex queries. A recursive function was defined on the client side to retrieve the whole object tree.

The problem list is a set of observations[1] which are also implemented as objects. Some of the attributes an observation on the problem list can have are "certainty", "severity", and "status." Capturing this information over time results in the creation of a pattern of problem related outcomes.

Like all other aspects of the CAC chart, the problem list is dynamically created. Since data entry is structured and logically categorized into a tree, all observations have labels. By highlighting any observation on the chart and clicking an icon, that observation is placed on the "Potential Problems Based on Observations" list. This is not part of the medical record. It represents the private "scratch pad" where each clinician may form his/her view of that patient's pertinent set of observations. Some set of these observations are then associated with a tree categorizing common problems of asthma. This broadly starts to model the differential diagnosis process.

The pattern or problem list becomes meaningful only when it is connected to the whole clinical process. Management plans, including orders are required to be related to problems before the chart can be electronically signed. Interventions ordered in management plans also have pre-intervention assessment measures and post-intervention evaluation measures. Over time, analyses of these outcome measures relative to their associated problems, orders, and plans can provide the basis for managed care scenarios, clinical pathways, and cost/benefit analyses. Further analyses on the probability that a given observation could be associated with a given diagnosis can be used to develop decision support tools.

Most importantly, patients and caregivers have benefited from the creation of these clinical patterns by being able to negotiate an individualized Asthma Action Plan for the self-management of the unique state of their disease. The design and implementation of online physician charting in the Children's Asthma Center truly supports the vision that Texas Children's

Hospital is dedicated to the finest possible pediatric care, education and research.

References

1. Rector AL, Nowlan WA, Kay S. Foundations for an Electronic Medical Record. Yearbook of Medical Informatics. 1992; 59-66.